(54) Title: MICROLITHOGRAPHIC PROJECTION EXPOSURE APPARATUS WITH IMMERSION PROJECTION LENS
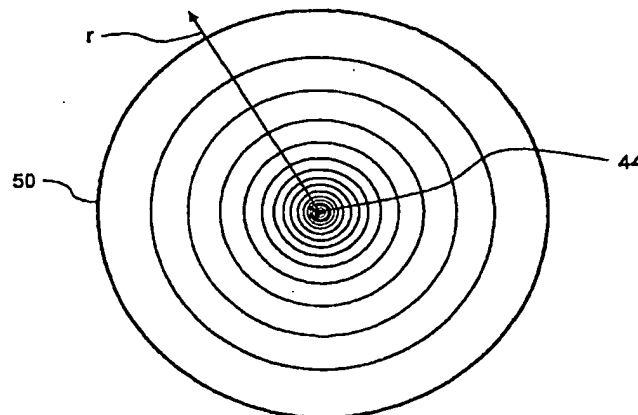
(57) Abstract: A microlithographic projection exposure apparatus includes an illumination system (12) and a projection lens (20) which images a reticle (24) on a photosensitive layer (26). The projection exposure apparatus (10) further includes an immersion arrangement (42) for introducing an immersion liquid (34) into an immersion interspace (35) between a last optical element (L5) of the projection lens (20) on the image side and the photosensitive layer (26). A transmission filter (50) is designed and to arranged in the projection lens (20) in such a way that rays which enter the immersion interspace (35) from the last optical element (L5) at an angle of incidence (α) are attenuated more strongly the smaller the angle of incidence (α) is. The transmission filter may be arranged e.g. in a pupil plane (48) of the projection lens (20) and may have a transmittance which increases with increasing distance from an optical axis (44) of the projection lens (20). In this way compensation is provided for angle-dependent absorption in the immersion liquid (34).

MICROLITHOGRAPHIC PROJECTION EXPOSURE APPARATUS
WITH IMMERSION PROJECTION LENS
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The invention relates to a microlithographic projection
exposure apparatus, comprising an illumination system for
generating projection light, a projection lens with which
a reticle which can be arranged in an object plane of the

5   projection lens can be imaged on a photosensitive layer
which can be arranged in an image plane of the projection
lens and is applied to a carrier, and comprising an im-
mersion arrangement for introducing an immersion liquid
into an immersion interspace between a last optical ele-

10   ment of the projection lens on the image side and the
photosensitive layer. The invention further relates to a
projection lens of such a microlithographic projection
exposure apparatus and to a process for the microlitho-
graphic manufacture of microstructured components.

15   A projection exposure apparatus, a projection lens and a
process of the above-mentioned type are known from
US 4 346 164.

Projection exposure apparatuses, of the kind used for
manufacturing large-scale integrated electrical circuits

20   .and other microstructured components, project structures
contained in a reticle on to a photosensitive layer which
may be applied, for example, to a silicon wafer.

One of the fundamental objectives in developing such pro-
jection exposure apparatuses is to be able to litho-
graphically define structures of increasingly small di-
mensions on the photosensitive layer. Small structures

5   give rise to high integration densities, which have a
generally favourable effect on the efficiency of the
microstructured components produced by means of such ap-
paratuses. The size of the definable structures depends
above all on the resolution of the projection lens used.

10   Because the resolution of the projection lens is in-
versely proportional to the wavelength of the projection
light, one approach to increasing resolution is to use
projection light with shorter and shorter wavelengths.
The shortest wavelengths currently used are in the ultra-

15   violet spectral range and are of 193 nm and 157 nm.

Another approach to increasing resolution is based on the
concept of introducing an immersion liquid into the space
intervening between the last lens of the projection lens
on the image side and the photosensitive layer to be ex-

20   posed. The immersion liquid preferably has the same re-
fractive index as the photosensitive layer, whereby the
numerical aperture is enlarged

The projection exposure apparatus known from the above-
mentioned US 4 346 164 has for this purpose an upwardly

25   open container which holds the carrier with the photosen-
sitive layer applied thereto. The container is filled

with an immersion liquid and is so arranged that the last optical element of the projection lens on the image side can be immersed in the liquid.

It has been shown, however, that although resolution can
5 be increased with the aid of the immersion method the contrast of the structures imaged on the photosensitive layer leaves something to be desired.

It is therefore the object of the invention to specify a projection exposure apparatus with which the advantages
10 of the immersion method can be exploited without having to accept significant losses in contrast.

In a projection exposure apparatus of the above-mentioned type this object is achieved in that the projection lens includes a transmission filter which is so designed and
15 arranged in the projection lens that rays which enter the immersion interspace from the last optical element on the image side at an angle of incidence α are attenuated more strongly the smaller the angle of incidence α is.

The invention is based on the discovery that the immer-
20 sion liquids which come into consideration, e.g. water or certain oils, are not completely transparent to the pro- jection light used but have a significant absorption co- efficient differing from zero. This causes a light ray passing through the immersion liquid to be absorbed more

strongly the longer the path travelled by the light ray
in the immersion liquid.

Because of the imaging characteristic of the projection
lens, rays from different directions strike every image
5   point on the photosensitive layer. Rays which enter the
immersion interspace parallel to the optical axis are
less strongly attenuated than rays which impinge on the
image point concerned at an angle with respect to the op-
tical axis. This is connected to the fact that the photo-
10   sensitive layer is arranged in the image plane of the
projection lens and is therefore flat. Consequently, for
a ray which, starting from a point on the image-side face
of the last optical element on the image side, passes
through the immersion liquid, the path travelled in the
15   immersion liquid is longer the larger the angle of inci-
dence at which the ray enters the immersion interspace
with respect to the optical axis. This is also the case,
of course, if the point in question is located on a face
which is not flat but curved.

20   If no corrective measures are taken, such an angle-
dependent reduction of radiation intensity for rays im-
pinging at an angle on an image point causes the entire
imaging process to lose contrast.

With the transmission filter according to the invention,
25   by contrast, rays of projection light which enter the im-
mersion interspace at an angle of incidence α with re-

spect to the optical axis are more strongly attenuated
the smaller the angle of incidence α. A lower overall de-
pendence of radiation intensity on ray direction is
thereby achieved. With appropriate design of the trans-
5   mission filter it can even be achieved that the rays of
projection light are attenuated in such a way that, for
all arising angles of incidence α, the rays have substan-
tially the same radiation intensity on striking the pho-
tosensitive layer.

10   The transmission filter may be arranged, for example, at
least approximately in a field plane, e.g. in the vicin-
ity of the image plane, of the projection lens and have
an angle-dependent transmittance which increases with in-
creasing angles of the rays with respect to the optical
15   axis.

Alternatively, a transmission filter in the form of a
normal neutral density filter may be used which is ar-
ranged at least approximately in a pupil plane of the
projection lens and the transmittance of which increases
20   with increasing distance from an optical axis of the pro-
jection lens. This arrangement makes use of the fact
that, with a transmission filter arranged in a pupil
plane, rays which enter the immersion interspace at a
predefined angle of incidence with respect to the optical
25   axis can be attenuated in a specified manner.

For example, all principal rays, i.e. rays which inter-
sect the optical axis in the pupil plane, exit the pro-
jection lens parallel to the optical axis and therefore
impinge perpendicularly on the image plane. For this rea-
5   son the principal rays travel the shortest distance in
the immersion liquid and consequently are least attenu-
ated in their radiation intensity by the immersion liq-
uid. To compensate for this, the transmission filter
preferably has the lowest transmittance in the region of
10   the optical axis. As a result, the principal rays are
most strongly attenuated by the transmission filter and
are least attenuated by the immersion liquid. By con-
trast, rays which pass through regions of the pupil plane
further removed from the optical axis impinge on the im-
15   age plane at larger angles and are therefore subjected to
stronger absorption by the immersion liquid. These rays
are therefore less attenuated by the transmission filter.

On a transmission filter arranged in a pupil plane, each
distance from the optical axis has associated with it a
20   particular angle of incidence at which the rays enter the
immersion interspace. To this extent the azimuth angle at
which a ray passes through the transmission filter is im-
material. For this reason the transmittance of such a
transmission filter can have a rotationally symmetrical
25   progression with respect to the optical axis. In the case
of a transmission filter arranged close to the field, the
angular dependence of the transmission capability is
preferably field-independent.

If the image-side face of the last optical element on the image side is disposed parallel to and at a distance d from the image plane, the dependence of attenuation on the angle of incidence α is preferably given by a trans-

5   mission function $T(\alpha)$ which depends on the absorption constant k of the immersion liquid and on distance d.

In this case, the particular transmission function $T(\alpha)$ can be given by the equation

$$T(\alpha) = T_0 \cdot \exp(kd/\cos(\alpha)) \ ,$$

10 where T_0 is a constant. This constant should preferably be selected such that for those rays of projection light which enter the immersion interspace 35 at the largest possible angle of incidence α_{max} with respect to the optical axis, the transmission filter has maximum transmit-

15 tance, preferably approaching 100%. In this case the constant T_0 is given by

$$T_0 = \exp(-kd/\cos(\alpha_{max})) \ .$$

Further advantages and features will be apparent from the following description of an embodiment with reference to

20 the drawings, in which:

Fig. 1   shows a meridional section through a projection exposure apparatus according to the invention

in a highly simplified representation which is
not to scale;

Fig. 2   shows an enlarged portion of the projection ex-
posure apparatus represented in Fig. 1;

5   Fig. 3   is a plan view of a transmission filter which
has transmittance increasing radially towards
the outside;

Fig. 4   shows a graph in which the attenuation gener-
ated by the transmission filter shown in Fig. 3
10   is plotted in dependence on the angle of inci-
dence with respect to the optical axis with
which projection light enters an immersion in-
terspace; and

Fig. 5   shows an enlarged portion of a projection expo-
15   sure apparatus according to a different embodi-
ment in a representation analogous to that in
Fig. 2.

Fig. 1 shows a meridional section through a microlitho-
graphic projection exposure apparatus designated as a
20   whole by 10 in a highly simplified representation. The
projection exposure apparatus 10 includes an illumination
system 12 for generating projection light 13, which in-
cludes a light source 14, an illumination lens system in-
dicated by 16 and a diaphragm 18. In the embodiment il-

lustrated the projection light has a wavelength of 193
nm. The projection exposure apparatus 10 further includes
a projection lens 20 containing a multiplicity of lenses,
only some of which are indicated by way of example in
Fig. 1 for the sake of clarity, and which are denoted by
L1 to L5. The projection lens 20 is used to image a reti-
cle arranged in an object plane 22 of the projection lens
20 on a reduced scale on a photosensitive layer 26 which
is arranged in an image plane 28 of the projection lens
and is applied to a carrier 30.

The carrier 30 is fixed to the bottom of an upwardly open
vat-like container 32 which is movable parallel to the
image plane 28 by means of a displacement device in a
manner not illustrated in detail. The container 32 is
filled with an immersion liquid 34 to a level at which
the last lens L5 of the projection lens 20 on the image
side is immersed in the immersion liquid 34 during opera-
tion of the projection exposure apparatus 10. Instead of
a lens, the last optical element of the projection lens
20 on the image side may be e.g. a plane-parallel closing
plate.

The container 32 is connected via a feed line 36 and a
discharge line 38 to a processing unit 40 in which a cir-
culation pump and a filter for cleaning immersion liquid
34 are contained. The processing unit 40, the feed line
36, the discharge line 38 and the container 32 together
form an immersion arrangement denoted by 42 in which the

immersion liquid 34 circulates while being purified and
maintained at a constant temperature. The refractive in-
dex of the immersion liquid, which may be e.g. water or
an oil, approximately coincides with the refractive index
5   of the photosensitive layer 26. Through the immersion of
the lens L5 in the immersion liquid 34 the projection
lens can be designed with a larger numerical aperture, so
that especially small structures can be defined on the
photosensitive layer 26 using the projection exposure ap-
10   paratus 10.

In the embodiment illustrated, the reticle 24 is a phase
mask with which the structures contained therein influ-
ence, not the intensity, but the phase of projection
light passing through same. Because the reticle 24 acts
15   as a diffraction grating for the projection light 13,
different orders of diffraction emanate from each point
on the reticle. Moreover, the reticle 24 is so designed
that substantially the totality of projection light 13
impinging on one point on the reticle 24 is diffracted
20   into the diffraction orders $m = 0$, $m = +1$ and $m = -1$.

This is illustrated in Fig. 1 for a point OP which is lo-
cated on the optical axis 44 of the projection lens 20.
The diffractive order $m = 0$ corresponds to undiffracted
projection light and is represented as the ray S_0, while
25   the diffraction orders $m = +1$ and $m = -1$ are represented
by diffracted rays S_{+1} and S_{-1}. The further ray path of

the rays S_0, S_{+1} and S_{-1} is indicated only schematically
in the projection lens 20.

In Fig. 2 an enlarged portion of the end of the projec-
tion lens 20 on the image side is illustrated. It can be
5 seen that the image-side plane face 46 of the last lens
L5 of the projection lens 20 on the image side is im-
mersed in the immersion liquid 34 which fills an immer-
sion interspace 35 between the last lens L5 on the image
side and the photosensitive layer 26. The ray S_0 which is
10 disposed along the optical axis 44 travels the shortest
possible distance d_0 in the immersion liquid 34, i.e. the
distance between the photosensitive layer 26 and the
plane face 46 of the lens L5 parallel thereto.

The two rays S_{+1} and S_{-1}, by contrast, enter the immersion
15 interspace 35 at an angle of incidence α with respect to
the optical axis 44. Because of this oblique entry into
the immersion interspace 35 the distance travelled
therein is d_α, where

$$d_\alpha = d_0/\cos(\alpha) \ . \tag{1}$$

Because the absorption coefficient k of the immersion
20 liquid 34 is homogeneous and isotropic, the rays S_{+1} and
S_{-1} are more strongly attenuated by the immersion liquid
34 because of the longer distance $d\alpha$, than the central
ray S_0.

If the radiation intensity of the rays S_0, S_{+1} and S_{-1} on
entering the immersion interspace 35 is I_0 in each case,
their radiation intensity $I(\alpha)$ after passing through the
immersion liquid 34 is yielded by

$$I(\alpha) = I_0 \cdot \exp(-kd_0/\cos(\alpha)) \ . \tag{2}$$

5   Through the greater attenuation of the rays S_{+1} and S_{-1}
inclined at an angle of incidence α with respect to the
optical axis 44, therefore, less light from the orders of
diffraction $m = +1$ and $m = -1$ reaches an image point IP
on the photosensitive layer 26 than light from the dif-
10 fractive order $m = 0$. As a result the image produced on
the photosensitive layer 26 has lower contrast than if
the intensities of radiation were distributed uniformly
over the orders of diffraction.

To ameliorate this situation and to achieve such uniform-
15 ity a transmission filter 50 mounted in a filter holder
52 is arranged in a pupil plane 48 of the projection lens
20. The transmission filter 50, which is shown in a plan
view in Fig. 3, has a transmittance which increases with
increasing distance from the optical axis 44. In the plan
20 view in Fig. 3 this is indicated by a plurality of con-
centric circles the spacing of which increases towards
the outside

In the transmission filter 50 shown as an example in Fig.
3 the transmittance T is rotationally symmetrical and is

therefore a function only of the radial distance r from the optical axis 44:

$$T = T(R) \ .\tag{3}$$

Because of the arrangement of the transmission filter 50 in the pupil plane 48, rays which pass through the trans-
5 mission filter 50 at a relatively large distance from the optical axis 44 enter the immersion interspace 35 at a larger angle of incidence α than rays which pass through the transmission filter 50 close to the optical axis 44. Because the transmittance of the transmission filter 50
10 is lower in that region, the last-mentioned rays are at-tenuated more strongly than rays which enter the immer-sion interspace 35 at a larger angle of incidence α with respect to the optical axis. In this way it is achieved that the attenuation according to equation (2), which in-
15 creases with increasing angle of incidence α, is overlaid by an attenuation generated by the transmission filter 50, which decreases with increasing angle of incidence α. As a result, more uniform overall radiation intensity for the rays of the different diffractive orders is produced.

20 The intensity of radiation becomes especially uniform if the product of the attenuation resulting from absorption in the immersion liquid 34 according to equation (2) and the attenuation resulting from absorption in the trans-mission filter 50 is a constant:

$$T(\alpha) \cdot I(\alpha) = \text{const .} \tag{4}$$

In this equation $T(\alpha)$ designates the transmittance of the transmission filter 50 as a function of the angle of incidence α at which the rays enter the immersion interspace 35.

5   From equations (3) and (4) the transmittance $T(\alpha)$ is then yielded as

$$T(\alpha) = T_0 \cdot \exp(-kd_0/\cos(\alpha)) . \tag{5}$$

So that as little projection light 13 as possible is absorbed overall by the transmission filter 50 the constant T_0 is preferably so defined that, at least for the rays

10   which enter the immersion interspace 35 at the largest possible angle of incidence α_{max}, the transmission filter has a highest possible transmittance, preferably $T(\alpha_{max}) \approx 1$. Insertion into the equation (5) then yields for the constant T_0 the relation

$$T_0 = \exp(-kd_0/\cos(\alpha_{max})) . \tag{6}$$

15   In Fig. 4 the progression of transmittance $T(\alpha)$ is plotted as a function of the angle of incidence α at which the rays enter the immersion interspace 35 with respect to the optical axis. It has been assumed that the distance from the surface 46 of the lens L5 to the photosen-

20   sitive layer 26 $d_0 = 4$ mm. The calculation is based fur-

ther on the assumption that water is used as the immer-
sion liquid 34 and is exposed to projection light having
a wavelength of 193 nm. The absorption coefficient k is
then k = 0.0321 1/cm. A value of 65° was used for the
5   maximum arising angle of incidence α_{max}.

It can be seen from the graph in Fig. 4 that transmit-
tance $T(\alpha)$ has the exponential progression yielded by
equation (5). In terms of absolute values, however, the
increase is relatively small, since even for an angle of
10   incidence $\alpha = 0°$ the transmittance is still greater than
0.982.

It should be noted in this connection that the transmit-
tance progression $T(\alpha)$ represented in Fig. 4 is not iden-
tical to the radial transmittance progression $T(r)$, as
15   indicated schematically in Fig. 3. The relation between
radial distances r and angles of incidence α is prede-
fined by the concrete design of the projection lens 20
and cannot be generalised without further specification.
Qualitatively, however, the radial transmittance $T(r)$ has
20   a similar progression to the transmittance $T(\alpha)$ repre-
sented in Fig. 4.

Fig. 5 shows in an enlarged section, in a representation
analogous to Fig. 2, the image-side end of a projection
lens according to a different embodiment of the inven-
25   tion. Parts identical to those in the above-described

projection lens are denoted by the same reference charac-
ters.

A transmission filter 50' having angle-dependent trans-
mission capability is fixed (in a manner not represented
5   in detail) to the plane face 46 of the last optical ele-
ment L5 on the image side. The transmission filter 50' is
therefore arranged close to the field, i.e. in the vicin-
ity of the image plane 28. Angle-dependent transmission
filters which are arranged in a field plane and which
10   cause angle-dependent attenuation are described in
WO 03/02256 of the applicant, the disclosure content of
which is included in its full extent in this application.

The angular dependence of the transmission capability is
so designed in the case of transmission filter 50' that
15   rays which enter the immersion interspace 35 at a larger
angle of incidence α are attenuated less strongly than
rays which enter the immersion interspace 35 at a smaller
angle of incidence α. With appropriate design of the an-
gular dependence it can be achieved in this case, too,
20   that all rays impinge on the photosensitive layer 26 with
approximately the same intensity.

Alternatively the transmission filter 50' may be arranged
in a field plane conjugate to the image plane 28, e.g. in
the vicinity of the object plane 22 or in an intermediate
25   image plane - if present - of the projection lens 20.

CLAIMS

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1. Microlithographic projection exposure apparatus,
       comprising an illumination system (12) for generat-
ing projection light (13), a projection lens (20) with
which a reticle (24) which can be arranged in an object
5   plane (22) of the projection lens (20) can be imaged on a
photosensitive layer (26) which can be arranged in an im-
age plane (28) of the projection lens (20) and is applied
to a carrier (30), and comprising an immersion arrange-
ment (42) for introducing an immersion liquid (34) into
10   an immersion interspace (35) between a last optical ele-
ment (L5) of the projection lens (20) on the image side
and the photosensitive layer (26),

characterized in that

the projection lens (20) includes a transmission filter
15   (50) which is designed and arranged in the projection
lens (20) in such a way that rays (S_0, S_{+1}, S_{-1}) which en-
ter the immersion interspace (35) from the last optical
element (L5) on the image side at an angle of incidence α
are attenuated more strongly the smaller the angle of in-
20   cidence α is.

2. Projection exposure apparatus according to claim 1,
       characterized in that the transmission filter (50)
is arranged at least approximately in a field plane of

the projection lens (20) and has angle-dependent trans-
mittance which increases with increasing ray angles with
respect to the optical axis (44) of the projection lens
(20).

5   3.   Projection exposure apparatus according to claim 1,
          characterized in that the filter is a transmission
filter (50) which is arranged at least approximately in a
pupil plane (48) of the projection lens (20) and the
transmittance of which increases with increasing distance
10 from an optical axis (44) of the projection lens (20).

    4.·   Projection exposure apparatus according to claim 3,
          characterized in that the transmittance of the
transmission filter (50) has a rotationally symmetrical
progression with respect to the optical axis (44).

15 5.   Projection exposure apparatus according to any one
          of the preceding claims, characterized in that the
transmission filter (50) attenuates the rays $(S_{+1}, S_0,
S_{-1})$ of the projection light (13) in such a way that for
all occurring angles of incidence α the rays $(S_{+1}, S_0,
20 S_{-1})$ have substantially the same radiation intensity when
impinging on the photosensitive layer (26).

    6.   Projection exposure apparatus according to any one
          of the preceding claims, characterized in that the
dependence of attenuation on the angle of incidence α is
25 yielded by a transmission function $T(\alpha)$ which depends on

the absorption constant k of the immersion liquid (34)
and on the distance d between the last optical element
(L5) of the projection lens (20) on the image side and
the photosensitive layer (26).

5   7.   Projection exposure apparatus according to claim 6,
            characterized in that the transmission function $T(\alpha)$
      is at least approximately yielded by

            $$T(\alpha) = T_0 \exp(-kd/\cos(\alpha)) \ ,$$

      where T_0 is a constant.

10   8.   Projection exposure apparatus according to claim 7,
            characterized in that the constant T_0 is at least
      approximately yielded by

            $$T_0 = \exp(-kd/\cos(\alpha_{max})) \ ,$$

      where α_{max} is the maximum angle of incidence at which rays
15   (S_{+1}, S_0, S_{-1}) enter the immersion interspace (35).

      9.   Projection lens of a microlithographic projection
            exposure apparatus with which a reticle (24) which
      can be arranged in an object plane (22) of the projection
      lens (20) can be imaged on a photosensitive layer (26)
20   which can be arranged in an image plane (28) of the pro-
      jection lens (20) and is applied to a carrier (30),

characterized in that

the projection lens (20) has a transmission filter (50)
which is designed and arranged in the projection lens in
such a way that rays (S_0, S_{+1}, S_{-1}) which enter the immer-
5   sion interspace (35) from the last optical element (L5)
on the image side at an angle of incidence α are attenu-
ated more strongly the smaller the angle of incidence α
is.

10.   Process for the microlithographic manufacture of
10   microstructured components comprising the following
steps:

     a)   providing a carrier (30) on which a layer (26) of a
           photosensitive material is applied at least par-
           tially;

15   b)   providing a reticle (24) containing structures to be
           imaged;

     c)   projection of at least a part of the reticle (24)
           onto an area of the layer (26) using a projection
           exposure apparatus (10) according to any one of
20   claims 1 to 8.

11.   Microstructured component which is manufactured
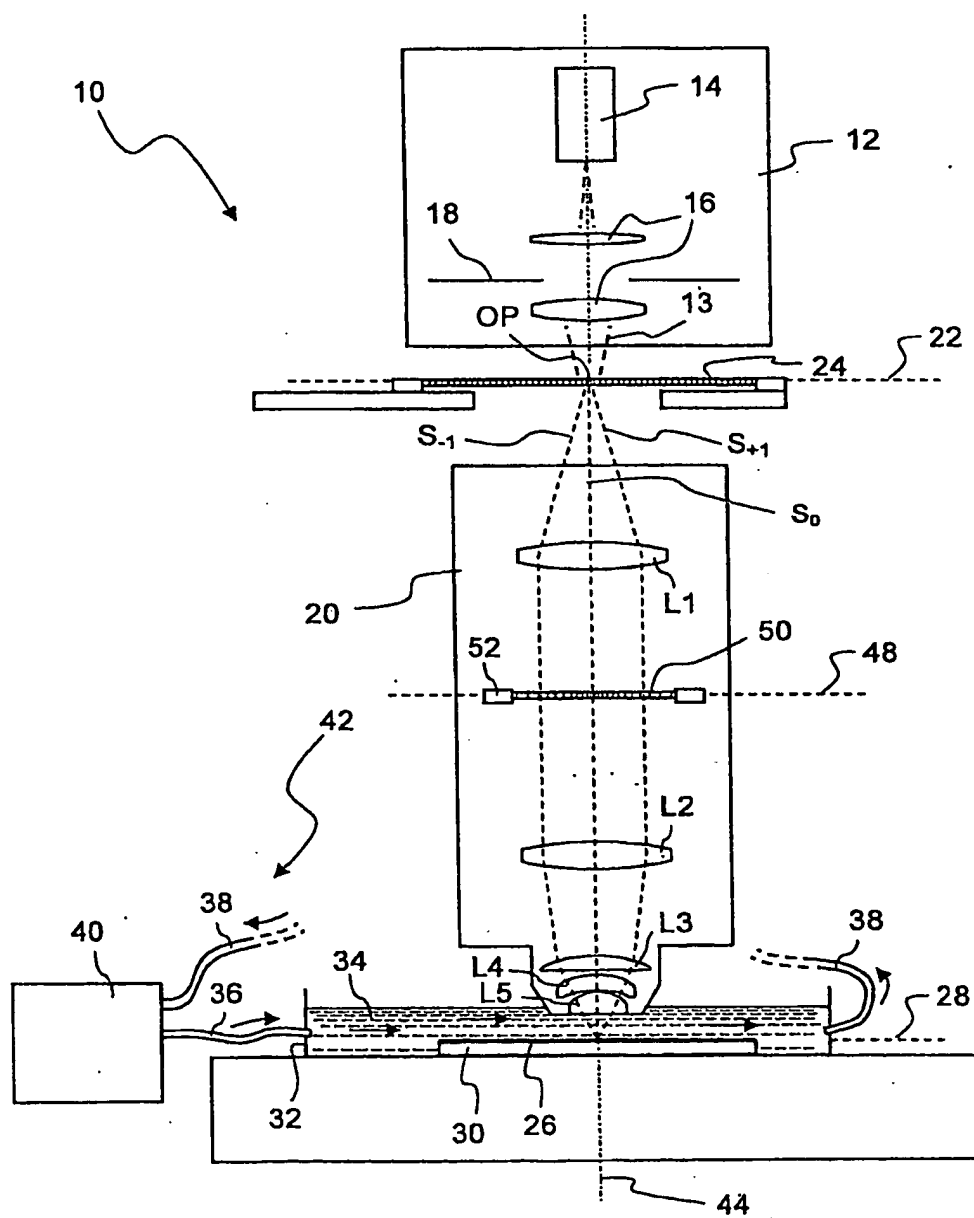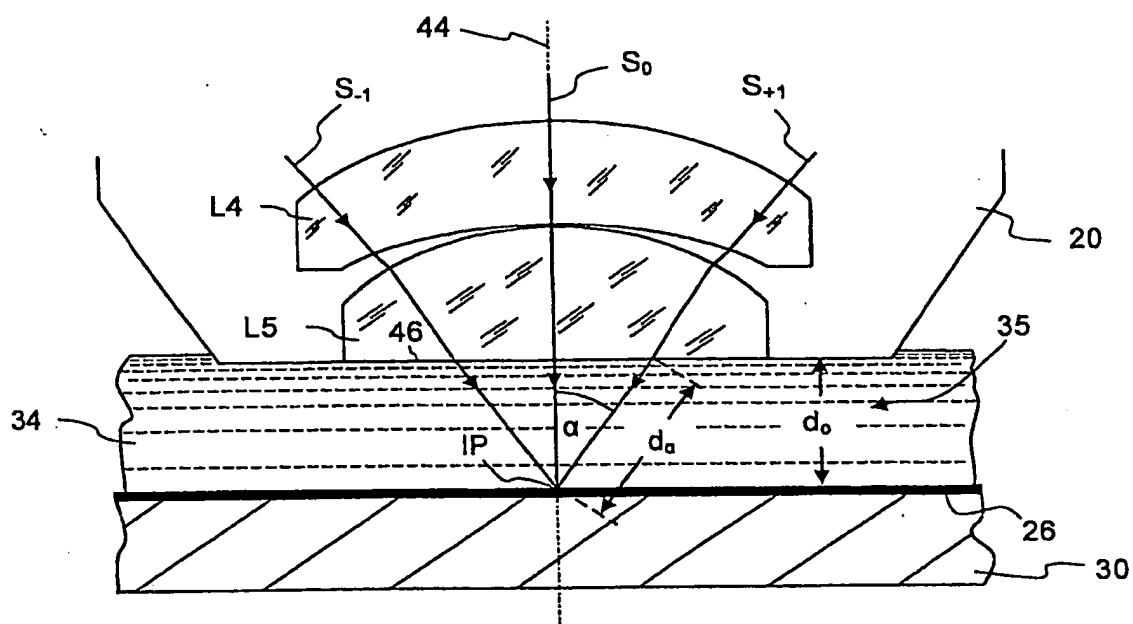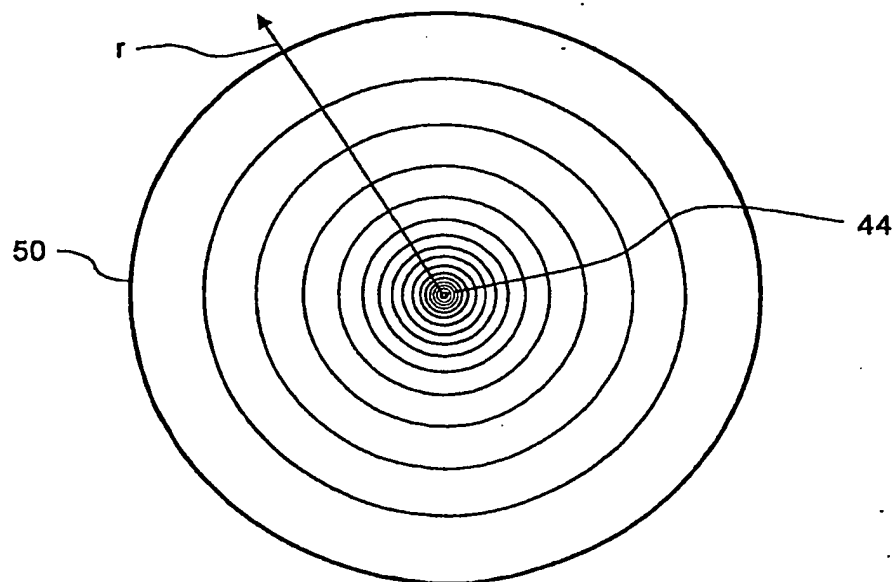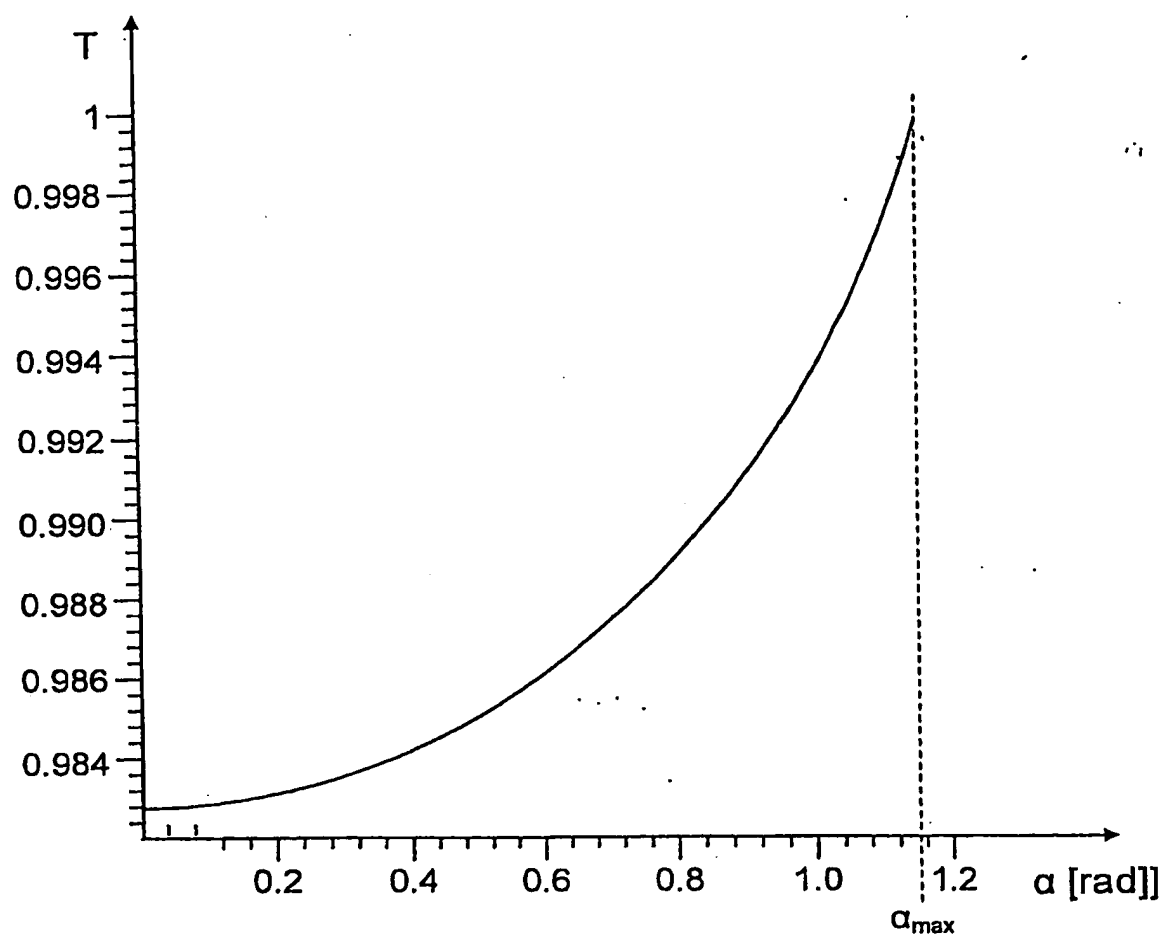   using the process according to claim 10.
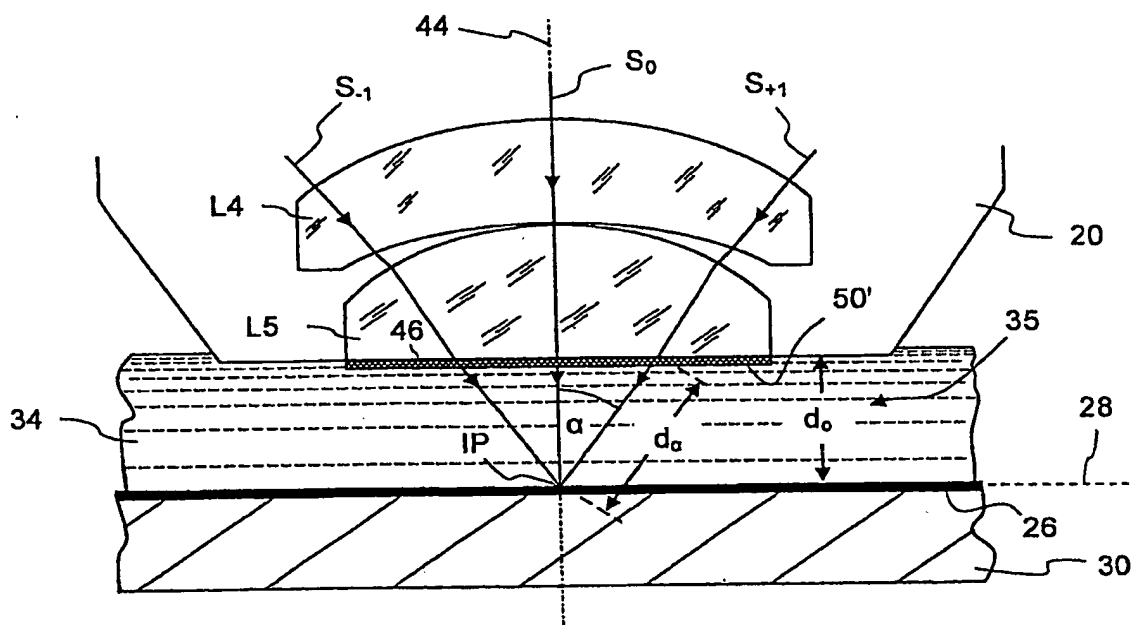
Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   G03F7/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   G03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 715 039 A (FUKUDA HIROSHI ET AL) 3 February 1998 (1998-02-03) column 2, line 43 – line 49	11
A	column 8, line 60 – line 67 column 14, lines 39-45; figure 13	1
A	WO 01/02907 A (SMITH BRUCE W) 11 January 2001 (2001-01-11) page 7, line 5 – line 9; figure 9	
A	WO 03/092256 A (CARL ZEISS SMT AG ; BRUNOTTE MARTIN (DE); GRAEUPNER PAUL (DE); GRAESCH) 6 November 2003 (2003-11-06) cited in the application figures 2,2a	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2005	01/02/2005

Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Authorized officer Eisner, K

INTERNATIONAL SEARCH REPORT

Information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5715039	A	03-02-1998	JP	8316124 A	29-11-1996
WO 0102907	A	11-01-2001	AU	6061000 A	22-01-2001
			EP	1203264 A1	08-05-2002
			JP	2003504861 T	04-02-2003
			WO	0102907 A1	11-01-2001
			US	2003112421 A1	19-06-2003
			US	6525806 B1	25-02-2003
WO 03092256	A	06-11-2003	DE	10218989 A1	06-11-2003
			WO	03092256 A2	06-11-2003